Some Useful Wire Antennas for HF

Part 1

Rob S Gurr VK5RG shares his comprehensive knowledge of wire antennas with us.*

When a new amateur operator makes his first enquiries to those already on the air, seeking advice on the best antenna to erect, he is frequently greeted with a short answer, which is actually an amateur callsign. "The G5RV" will be the response from some, the "G8PO" from others, and perhaps even the "ZL Special" from a few. Others may recommend a "W8JK", a "HB9CV", or a .....These names mean very little to a beginner who is looking to establish his own station. What do these and other similar titles mean, and what benefits does he get by using such an antenna? Why are there so many choices, and why can't he go straight to the best type, fully confident that it will work first try? In this article I will discuss the above antennas, and also describe some other very useful HF wire antennas which, as yet, have not been given a title that identifies a person, rather than a physical item. Firstly, though, a few general matters about antennas.

Some Wire Antenna Considerations

The Wire

A 100 metre reel of 2.5 mm^2 stranded copper earth wire with PVC insulation costs about $35.00 from electrical trade outlets. Don't buy it by the metre at retail hardware shops or you may pay up to three times this price. One hundred metres may last a long while; however, a friend may share the cost with you. In most cases, by the time an antenna and feedline are constructed, there will be little surplus. Also available is electric fence wire, from farming supply outlets; a sample reveals this to be multi-stranded steel wire, with one conductor of copper.

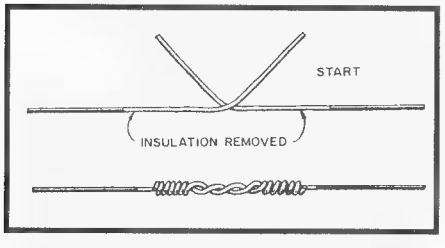

Figure 1 – Splicing antenna wire.
(Reprinted from The ARRL Antenna Book 15th Edition, page 21-3)

Connectors

Soldering wire joints outdoors is not always practical. The use of commercial brass earth connectors, such as Clipsal Type 563/2, or similar, is recommended. These may be covered over with insulation tape or, additionally, silicone rubber, if improved weatherproofing is required. The soldered joint is to be preferred; however, it should be a mechanically suitable joint, with wires twisted a number of times, or clamped, before solder is applied. I have had satisfactory experience with the "Post Office", or "Lineman's Joint", and find them quite suitable for copper wire aerial connections (see Figs 1 & 2).

Masts

Steel tubes, sectionalised masts, wooden or bamboo poles are all suitable. The use of trees, house fascias, and other elevated supports is also possible, providing suitable anchoring techniques are used. "U" bolts, turnbuckles, etc, are a standard hardware shop line. Height above ground will generally legally be restricted to 10 metres. However, if you are willing to obtain the necessary permit, heights up to 15 metres may be used in a number of suburban installations. There is, unfortunately, a significant disadvantage in using this additional height on some frequencies. With trees, due to wind sway, use of halyards and pulleys utilising springs and counterweights is recommended. Wet foliage under certain circumstances may be a problem.

Guy Wires

Stranded steel galvanised wire may be used, and often surplus stainless steel rope is available. Joints can be made using clamps, turn-buckles and thimbles, as well as the above-mentioned Post Office splice

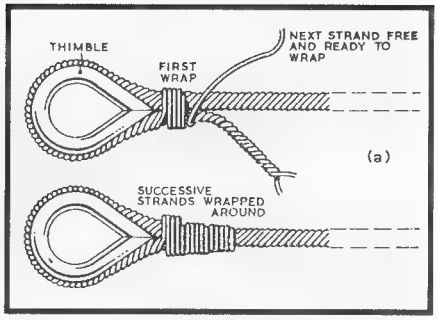

Figure 2 – The "Post Office" splice for securing stranded wire around a thimble or insulator.
(Reprinted from the RSGB Radio Communication Handbook, fifth edition, page 12.91)

(see Fig 2) method. It is good practice to use insulators liberally (about every 3 metres), however, if a one-length guy wire is preferred, an insulator at the top and bottom is essential. This requirement is to ensure that the length of wire associated with any unbonded metal-to-metal contact (thimble through the eye of a turnbuckle) is as short as possible. This prevents large signal pickup and subsequent re-radiation should corrosion at the junction occur. We are all familiar with unexplained "crackles" on our receivers, and also with cross-modulation involving broadcast stations, which mysteriously worsens on dry windy days!

Should it be necessary to have a long length of guy wire, or a cable catenary system that cannot be broken up with insulators, all metal to metal flexible contacts should be bonded over, or liberally coated with a graphite (conducting) grease; EMF Welder Grease, by Golden Fleece, has been my favourite, but other brands are available. It is not necessary to break guy wires into short sections using insulators. If you are inclined to do so, break them at quarter wavelengths on the highest frequency in use, ie every 2.5 metres for 28 MHz.

Transmission Lines and Spreaders

The construction of a suitable open wire line can be simplified by the use of 16 mm, or 20 mm, heavy duty electrical conduit.

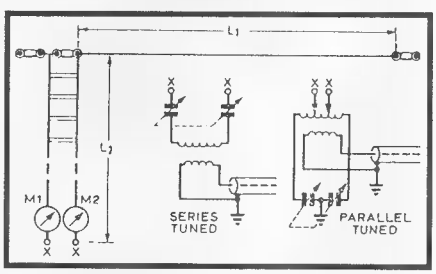

Figure 3 – End Fed Zepp.
(Reprinted from the RSGB Radio Communication Handbook, fifth edition, page 12.61)

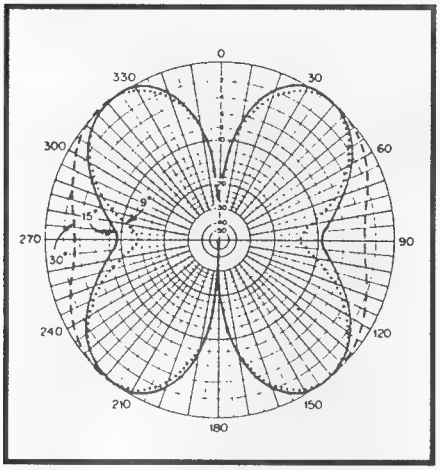

Figure 4 – Horizontal patterns of radiation from a full-wave antenna.
(Reprinted from the ARRL Handbook, 1988 Edition, page 17-8)

Doubts may be held by some readers about the suitability of plastic as an insulator for feedlines in this manner, but I don't think a contact has ever been lost due to such small losses. Another insulator material, already protected for UV radiation, is the popular black garden automatic water sprinkler hose, about 4 mm diameter.

Feedlines should be drawn away from antenna arrays at right angles, particularly where close to towers and other metallic supports. The use of UPVC to ensure minimum deterioration due to ultraviolet radiation is not considered necessary. Holes in the conduit to allow the wire to pass through, and a smaller diameter tie wire to prevent the spacer slipping down the feedline are required.

Textbooks and practical experience vary. A line constructed for 300 to 800 ohms would be suitable in most cases, eg the 300 ohm open wire TV ladder line is satisfactory; however, do not use any other type of 300 ohm commercial feed line. A home-made line, of spacing between 50 and 150 mm is recommended, with spacers installed every 300 mm for narrow spaced lines and every one metre for wide spaced lines.

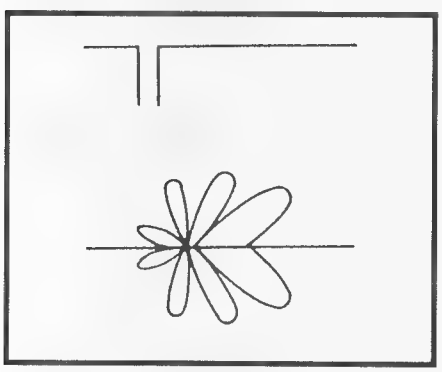

Figure 5 – Radiation pattern of a long wire antenna fed from a low impedance point near one end.
(Reprinted from the Radio Handbook, twenty-first edition, page 28-3)

Lines could be pulled tight, but a loose hanging line with no right angle bends is acceptable. Wind sway may be a minor problem unless the lines are running close to earthed metal surfaces such as roofs, towers, etc. I would inject a word of warning here. Do not treat a tiled roof as an unearthed surface. Usually below the tiles you will find hot and cold water, and gas pipes, electrical wiring, TV antennas and associated cables, telephone wires, etc, all of which have an influence on any nearby aerials or feedlines. The entry of the feedline (2 x 2.5 mm^2 insulated copper stranded wire) to the radio room is best via feed-through insulators; there are many variants available, most of which suggest themselves.

Do not run through a metal frame window and close the window on the line. The window may be at a quarter wave point and the high voltage will burn the insulation through, and so on. Brickwork entry is possible using small diameter glass tubes in mortar courses, etc.

Be certain to maintain the same spacing between the conductors for the full length of the line to the ATU. A good test of a feedline is to listen on it, through the ATU, when the aerial is disconnected. If you hear nothing, then it is balanced.

It is good practice to have an integral number of quarter waves in a feedline; however, random lengths do not inhibit good results, they only make the ATU work into complex reactive loads.

In some cases a number of ATUs, tuned for separate bands, may be remotely located and fed from the transmitter through coaxial cable.

Element Spreaders

Spreaders for separating the elements can also be made from electrical conduit, with a wooden dowel, or fibreglass rod, inserted internally to give rigidity. The conduit lengths available are regrettably a maximum of four metres. Some ingenuity may be required to make simple spreaders longer than this. Aluminium tube, 25 mm in diameter, may be suitable for up to five or six metres and, as it is usually at right angles to the antenna wires, should have little effect on radiation. Short aluminium tube lengths may be also used for joining wooden dowels, prior to enclosure in PVC conduit. Conduit end caps (Clipsal 252 series) are recommended, to finally enclose the spreader.

Fibre glass rods may also be fabricated to form elongated "cages" for spreaders up to five metres long.

Coupling Units

Most of the antennas to be described are balanced and symmetrical. The feedlines are not always "flat" (SWR terminology) and the impedances presented at the amateur equipment may vary from less than 20 to over 1000 ohms. Most multipurpose ATUs ("Z" Match, "T" match with balun) may be adjusted, with the assistance of a suitable SWR meter, to convert these impedances to 50 ohms to interface with standard amateur equipment. The description of a suitable ATU is included at the end of this article.

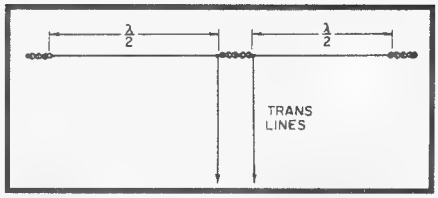

Figure 6 – A two-element collinear array (two half waves in phase).
(Reprinted from The ARRL Antenna Book 15th Edition, page 8-32)

Earthing Systems

It is desirable for all aerial installations to have a good RF earth, and when using end-fed wire antennas (verticals or horizontal), it is essential. There are many practical reasons for this, and if one very good earth point can be established immediately adjacent to the ATU, and all other equipment bonded back to this point, it should be sufficient for most applications. The earth lead should be as short as possible as the ATU is part of the antenna system. All bonding earths to equipment are ancillary to this main lead.

(It should be remembered that the amateur equipment itself should be separately earthed through the three wire power cable. The General Purpose Outlet, and the whole electrical system, all complying to the requirements of the SAA Wiring Rules AS3000).

A suitable earth stake may be a two metre length of 20 mm water pipe driven

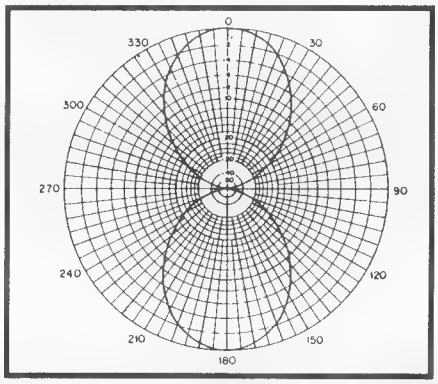

Figure 7 – Free-space E-plane directive diagram for a two-element collinear array.
(Reprinted from The ARRL Antenna Book 15th Edition, page 8-32)

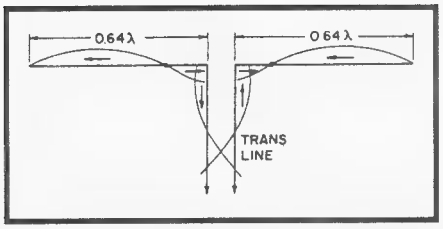

Figure 8 – The extended double Zepp. This system gives somewhat more gain than two half-wave collinear elements.
(Reprinted from The ARRL Antenna Book 15th Edition, page 8-34)

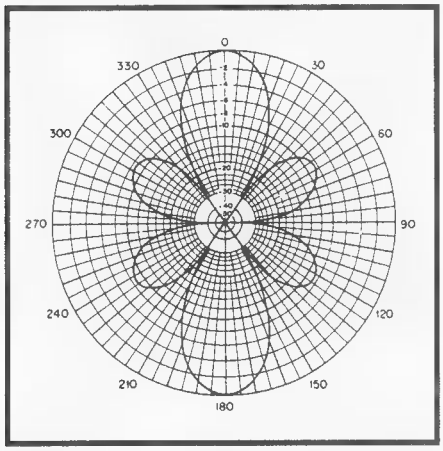

Figure 8a – E-plane pattern for the extended double Zepp.
(Reprinted from The ARRL Antenna Book 15th Edition, page 8-34)

into the ground, with a standard electrical earth clamp for connection of the wire. In the case of end-fed wires, or ground planes, all nearby exposed metal such as carport supports, roof decking, galvanised fences, domestic water pipes, should be bonded back to the earth stake. A suitable wire is 6 mm^2 insulated earth wire (Green/Yellow) from an electrical trade outlet. Remember, the longer the earth lead, the higher the ATU is above radio frequency ground. The reason you get "bites" from microphone cases and equipment is that these items are often a quarter wave above ground where a high RF voltage exists.

Never rely on the mains earth as it may be a long way to the main switchboard, and even longer to the main earth stake. These aspects are most important in the end-fed antenna situation. In a practical situation, most amateurs should be able to achieve an earth wire of no more than a metre in length. Do not place your ATU at the top of everything else, or you may easily encounter that undesirable quarter-wave!

End Fed "Zeppelin"

A halfwave dipole, fed at one end with a non-radiating feedline, exhibits bi-directional radiation properties near its resonant frequency and on lower frequencies only (see Fig 3). At higher frequencies, major and minor lobes appear and its use on harmonics for multiband operation provides useful gain, particularly when considering harmonics above the fourth or fifth (see Fig 4).

One such aerial is usually known as the end-fed "Zepp". Actually, the figure eight pattern of the dipole radiation, and symmetry of the lobes on harmonics, is somewhat distorted, to give a directional radiation away from the feeder end (Fig 5). These aspects are worthy of further reading; however, for a "backyard" installation, its application is somewhat limited if directivity is required. The above aspects do not preclude the end-fed dipole being used as the driven element of a co-linear phased array. In fact, some physical layouts may require such a feed (sometimes the line of support poles may be at right angles to that necessary for the use of an alternative directional array). Such arrays stay bi-directional, in a direction at right angles to the line of their support masts.

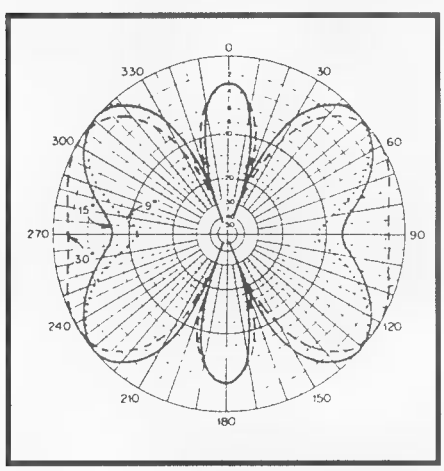

Figure 9 – Horizontal patterns of radiation from an antenna three half-waves long.
(Reprinted from the ARRL Handbook, 1988 Edition, page 17-8)

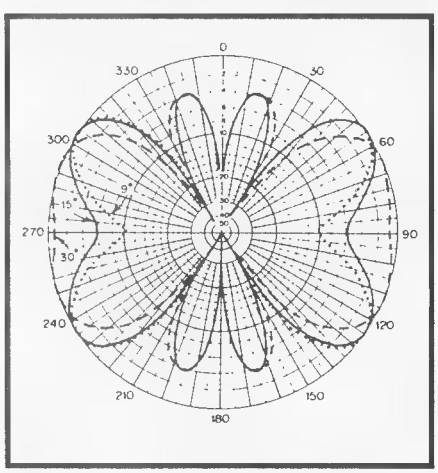

Figure 10 – Horizontal patterns of radiation from an antenna two wavelengths long.
(Reprinted from the ARRL Handbook, 1988 Edition, page 17-8)

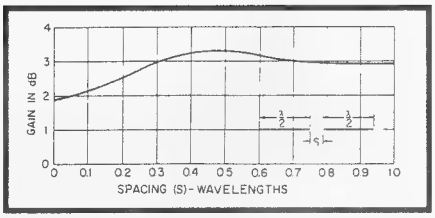

Figure 11 – Gain of two collinear half-wavelength elements as a function of spacing between the adjacent ends.
(Reprinted from The ARRL Antenna Book 15th Edition, page 8-32)

Centre Fed "Zepp"

An array of two in-line (collinear) half-wave elements (Fig 6), fed in the centre with a tuned feeder, exhibits a gain of 1.8 dBd (4 dBi) (see Fig 7). This is known generally as two half waves in phase. By extending the dipole lengths to 5/8 wave, the array becomes two extended half-waves in phase (Double Extended Zepp), with a gain of 3 dBd (5.2 dBi) (see Fig 8). Such an antenna, usually with end feed, is well known to 144 MHz operators as a "Ringo".

When such an array is erected and tuned for 14 MHz, it is coincidentally two half waves in phase on 10.1 MHz. On 7 and 3.5 MHz the array is effectively a long dipole, and a short dipole respectively, but with still the same bi-directional radiation. We now have a bi-directional array for 3.5 to 14 MHz, with a useful gain on both 10 and 14 MHz. On higher bands the bi-directional lobes are replaced by multiple lobes (Fig 9), at various angles, however the main lobes continue to exhibit even higher gain. Regrettably, they may not be in the direction that you may wish to frequently contact (Fig 10).

Specific dimension for this is simply calculated by assuming a design frequency of 10.1 MHz, where a half wavelength is 14.85 Metres. This gives a somewhat improved DX performance on the G5RV (mentioned later), where bidirectional properties occur on the 3.5 and 7 MHz bands only, and multi-directional lobes become evident on 10.1 MHz.

As an ATU is necessary to get multi band operation from this antenna and a G5RV, this shorter antenna has more to offer.

Maximum gain possible in any combination of two dipoles is 3 dBd, ie two arrays with unity power can only produce twice power under any condition. This is an important fundamental in understanding antenna gain (Fig 11).

Part 2 of Some Useful Wire Antennas for HF will appear in next month's issue of *Amateur Radio.*

**35 Grandview Avenue, Urrbrae SA 5064*

■ Antennas

Some Useful Wire Antennas for HF

Part 3

Rob S Gurr VK5RG concludes his series on wire antennas.*

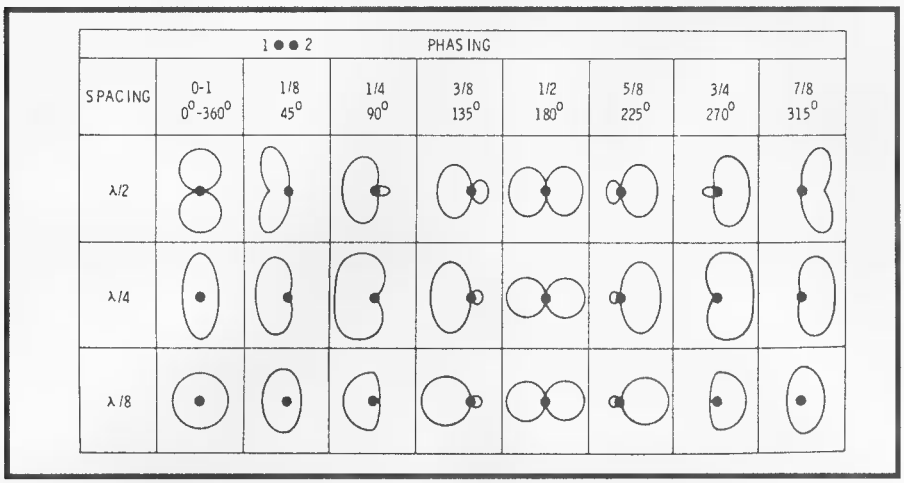

Figure 22 – Radiation patterns for a two element phased array.
(Reprinted from the Radio Handbook, twenty-first edition, page 27-12)

Quarter Wave Sloper

This must be the cheapest effective and useful antenna available. In the simplest form it may be considered a quarter wave vertical, but fed at the top instead of the bottom. The "ground plane" is the support tower and the mass of the other beams and antennas mounted on the tower. I have fabricated a mast clamp that enables me to secure it to the top of a tower, and from this clamp have run a quarter wave wire to a nearby pole or tree. A coaxial cable socket is available to connect the feedline. Tuning is by altering the length of the wire a few inches either way, as guided by an SWR reading, or noise bridge.

The initial SWR should be quite low; however, it may be improved by moving the bottom of the wire from place to place in the yard. Best SWR may sometimes be time consuming to achieve, but it will be worth it. The antenna has a low angle of radiation, and on 7 MHz has provided me with USA contacts that have not been possible on a centre fed dipole. If you have a tower and a spare coax running to its top, this is a "Bonus" antenna.

Full Wave Loop

The use of a full wave horizontal loop at a very low height has become popular throughout the world in recent years. Erection of a large multiband array in a moderate size suburban backyard has been the wish of many hams. Although not large, the full wave loop has a great deal to offer.

In its general configuration, a full wave of wire is suspended (as a square of equal sides), at between three and ten metres above the ground. One corner, or the centre of one side, is fed with open wire line and the array matched at whichever frequency is desired. The radiation is predominantly through the plane of the antenna and, therefore, directly vertical to the ionosphere. This is of great assistance, as reflected power is toward the ground and may spread over up to 1,000 km.

There is a need to consider some aspects of the ionosphere to understand the working of such an antenna:

1. The ionosphere surface is not a clear reflecting plane as is a glass mirror. It is a most uneven surface, with sections so irregular in shape, that reflections may occur at many angles, hence the resultant broad geographic coverage (both on long distance hops or local vertical incidence paths as in this case).

2. There is a frequency above which the radio wave is absorbed by this surface, varying from time to time, season to season, known as the critical frequency.

The overall benefits of such an antenna are, therefore, good low frequency coverage over a local path and at no great expense of supports. Above the critical frequency, at perhaps 14 MHz, random lobes from the horizontal wires, which may have a reasonably low angle of radiation, can give acceptable DX performance.

A number of such low antennas may be used for multiband work. I mention them mainly in the context of their low frequency usefulness. A typical antenna may be erected as a 10 metre-a-side loop on three metre high masts, or on short poles protruding from the top of fruit trees, and give a 7 MHz signal into a nearby state comparable to a full size dipole at 15 metres, used by another ham for DX work. The principle here is never to consider your back yard too small to erect an antenna which will be effective in some way or other! The point at which such a loop is fed is more a matter of convenience than an electrical requirement, although the need to retain symmetry should be observed. I have seen some fed with coaxial cable via a balun; however, the practicality of using it on a number of bands makes the use of open wire line very attractive.

Alternative Forms

I have encountered many of these antennas with a terminating resistor opposite the feedline point, as well as some with an open circuit at this point. These may provide some with an experiment or two to work out the worth of such modifications.

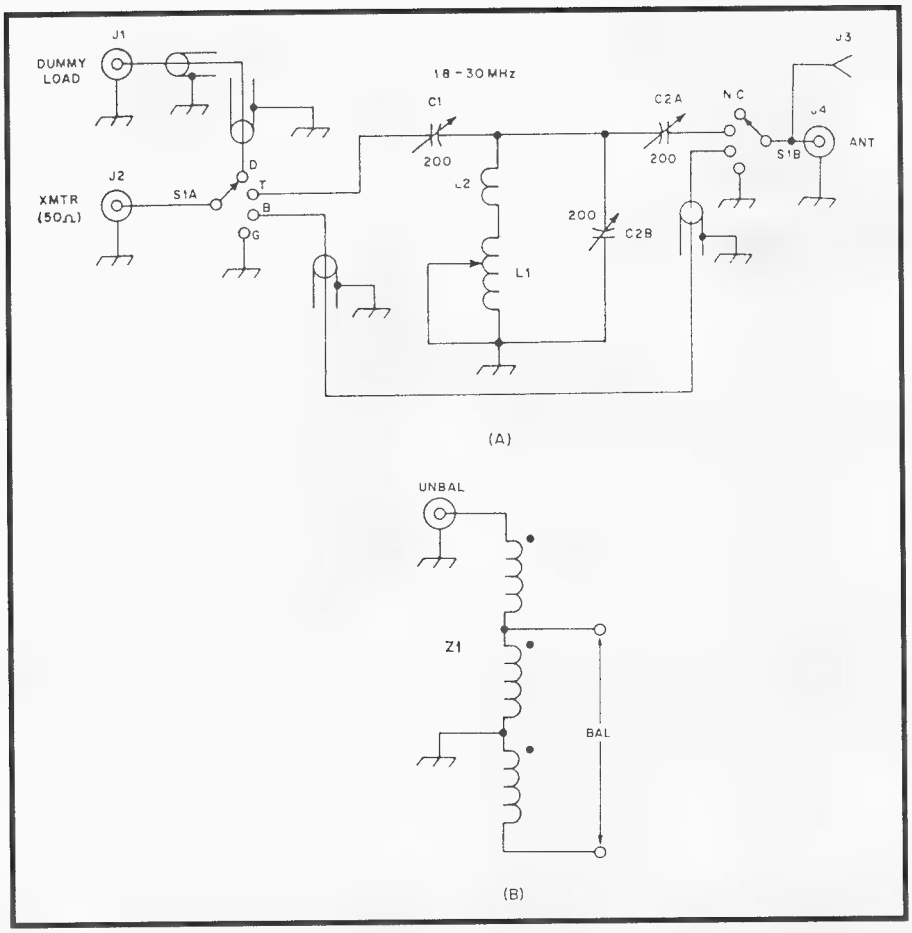

Figure 23 – Schematic diagram of the SPC transmatch. Capacitance is in picofarads.
(Reprinted from the ARRL Handbook, 1988 Edition, page 34-16)

Antenna Tuning Unit

Coupling the feedline of the antenna to a transmitter is arranged through an antenna tuning unit (ATU). This item may be treated as a "black box" that matches the impedance found at the end of our feedline, on the various bands, to the 50 ohm load impedance of our transceivers. The feedline lengths may be chosen to arrange for either a current or voltage node to be present at the ATU terminals, where either a series or parallel resonant tuned circuit would simplify the adjustments.

Modern tuning units of the "SPC" (Fig 23) or "Z Match" (Fig 24) designs are more tolerant to complex impedances and it is not necessary to use "resonant" feedline lengths with these. The components within these ATUs are altered, by the adjustment of the controls, for a reverse power between the transmitter and the ATU of zero. This completes the matching process.

Z Match Antenna Tuning Unit

The Z match antenna coupling unit has been very popular for a number of years, since it was featured in ARRL and RSGB publications, and more recently in *Amateur Radio* magazine. Many units have been described using an assortment of coil dimensions and layouts, including single and two coil set ups, and units to cover from 1.8 to 30 MHz.

I have had success with the RSGB version (Fig 24), which covers 3.5 to 30 MHz only, and have now successfully built a number of these. My modified version has been copied by several VKs, and while the RSGB description gives excellent information on coil construction, the suggested layout gives extremely long leads to the 14-30 MHz range coil, which is overcome in the modified version (Fig 25).

This layout places the higher frequency coil directly between the fixed terminal lugs on the two gang (H gang!) capacitor. On both the RSGB and ARRL circuits, each link is marked for 3.5/7 or 14/21/28 MHz, which has caused difficulties for many constructors, as some feedline lengths present impedances to the coupler which may be matched better by the alternative connection.

I solved this problem by using a 3-position, 2-pole switch which allows the twin feeder to be connected to either link (positions 1 and 2) or to the external terminal mounted on the rear panel of the coupler (position 3). This last terminal allows the twin feeder to be used as a top-loaded vertical antenna on 1.8 MHz through an additional antenna coupler, or as a general coverage receiving antenna.

The coils may be 63 mm and 75 mm in diameter, as shown in the diagrams, and 14 to 16 SWG wire is suitable. The coils should first be wound around a cylindrical former (eg an electrolytic capacitor) of smaller diameter, and then threaded into the holes in the perspex support. A suitable adhesive (eg plastic

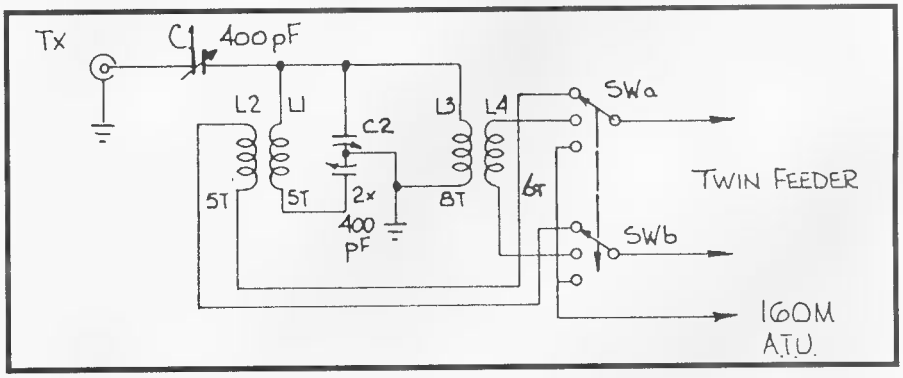

Figure 24 – The Z Match.
(Reprinted from Amateur Radio, September 1984, page 17)

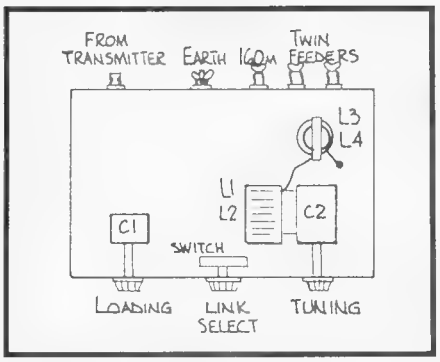

Figure 25 – The Z Match layout.
(Reprinted from Amateur Radio, September 1984, page 17)

cement) may be used to fix the coils in the holes (Fig 26).

For power up to 100 watts, standard single- and two-gang broadcast receiver tuning capacitors are quite suitable, with Stromberg "H" gangs preferred. For higher power, a pair of transmitting variable capacitors, with adequate plate spacing, should be used. Note that C1 needs to be insulated from ground and from the COUPLING control knob. The frame and rotor of C1 should be connected to the transmitter output, while the stationary plates should be connected to L1.

A most essential requirement is the use of vernier dials on the drive shafts of the two capacitors. It is impossible to tune capacitors of these maximum values with the fine accuracy needed to set the match correctly, without such dials.

The "Z" match is constructed on a simple U-shaped chassis, with a second U-shape of perforated metal as a top cover. The front panel controls are LOADING, LINK SELECTION and TUNING.

The unit should be used with a good earthing system. A minimum 1.5 m length of 20 mm galvanised water pipe should be driven into the ground immediately behind the antenna coupler and, from an earth clamp on this pipe, a length of 6 mm^2 or larger copper wire run to the earth terminal on the ATU. One to two metres of wire should be enough. Additionally, bonding of this earth system to nearby water pipes, galvanised steel carports or other metallic structures will improve efficiency when using unbalanced-feed antennas.

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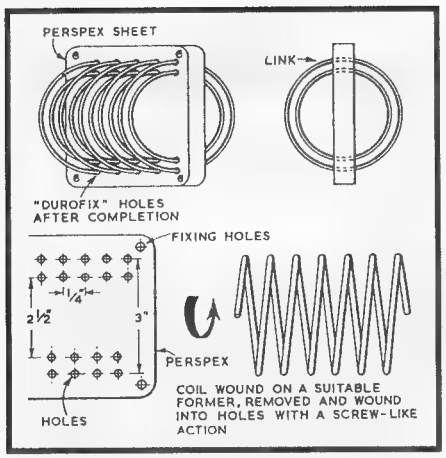

Figure 26 – Coil construction for the Z Match.
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Dipoles

In Fig 27 I have presented 15 ways of feeding a half wave dipole – there are surely more! Few of these may be used with multiband wire antennas; however, all give a great basis for further experimentation with antennas.

It may come as a surprise to a large proportion of readers that there are so many possible methods. I offer them as a starting point for your next antenna matching experiments.

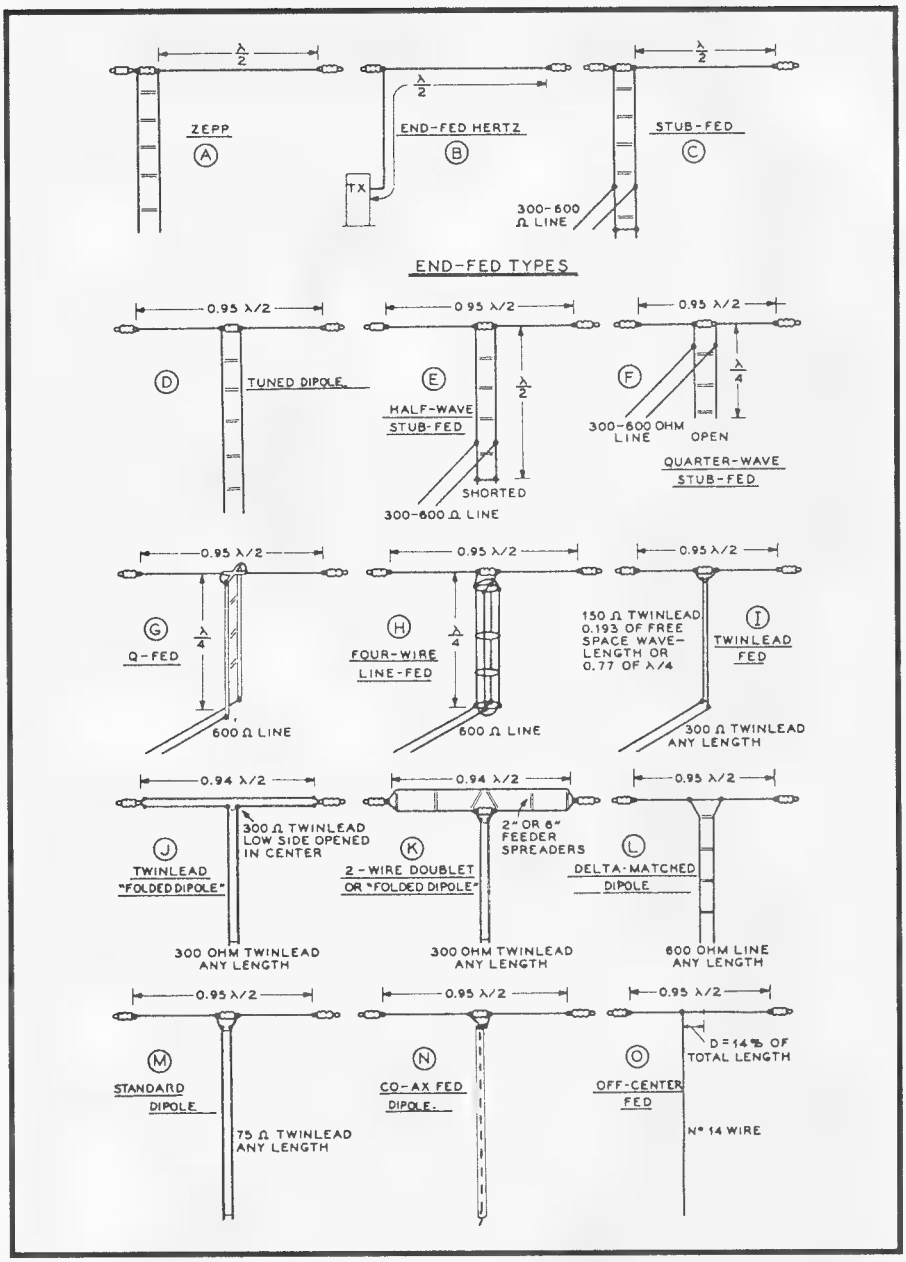

Figure 27 – Feed systems for a half-wave dipole antenna.

Conclusion

I have presented some useful antennas in this article. Some basic details have been supplied and a few hints given on methods of construction. No paper on this very broad subject can be complete in all details; however, I refer you to the list of publications, to read, and conduct experiments with some of my comments in mind.

I am sure you will have plenty of fun, learn a lot about antenna theory, and obtain plenty of contacts with all parts of the world. I cannot help solve the current high frequency propagation problems. However, with a suitable antenna, you should have good contacts when the various bands are open.

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Gain of V Beam

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On energy-conservation grounds it may be argued that absorbing some power in the resistors, which would otherwise be radiated in a particular direction, cannot increase the power radiated in another direction. The front-to-back ratio will become large, but to expect further gain (approaching 3 dB) is rather optimistic.

It may be, because in the terminated case the current distribution along the wires is a travelling wave, not a standing wave, that the energy-conservation concept is an over-simplification and some additional gain may in fact be possible; but it is likely to be much less than 3 dB.

WIA News

Propagation and Ionospheric Data on the World Wide Web

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■ Antennas

Some Useful Wire Antennas for HF

Part 3

Rob S Gurr VK5RG concludes his series on wire antennas.*

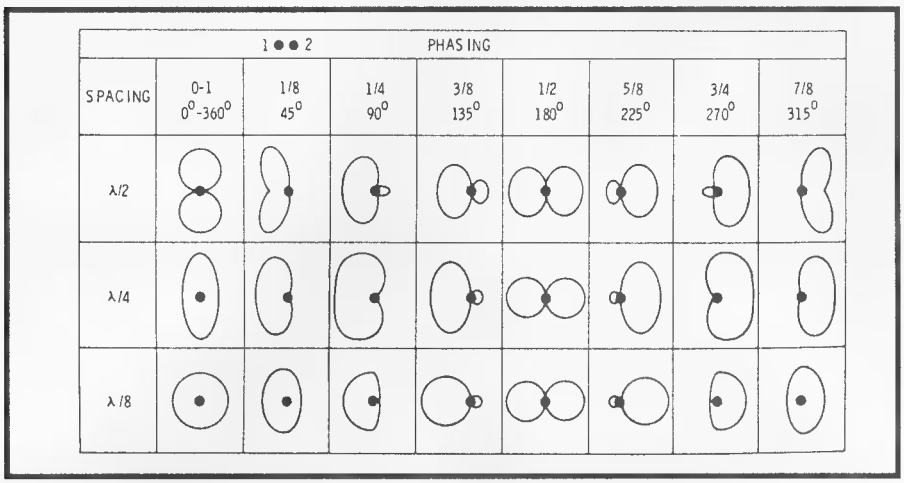

Figure 22 – Radiation patterns for a two element phased array.
(Reprinted from the Radio Handbook, twenty-first edition, page 27-12)

Quarter Wave Sloper

This must be the cheapest effective and useful antenna available. In the simplest form it may be considered a quarter wave vertical, but fed at the top instead of the bottom. The "ground plane" is the support tower and the mass of the other beams and antennas mounted on the tower. I have fabricated a mast clamp that enables me to secure it to the top of a tower, and from this clamp have run a quarter wave wire to a nearby pole or tree. A coaxial cable socket is available to connect the feedline. Tuning is by altering the length of the wire a few inches either way, as guided by an SWR reading, or noise bridge.

The initial SWR should be quite low; however, it may be improved by moving the bottom of the wire from place to place in the yard. Best SWR may sometimes be time consuming to achieve, but it will be worth it. The antenna has a low angle of radiation, and on 7 MHz has provided me with USA contacts that have not been possible on a centre fed dipole. If you have a tower and a spare coax running to its top, this is a "Bonus" antenna.

Full Wave Loop

The use of a full wave horizontal loop at a very low height has become popular throughout the world in recent years. Erection of a large multiband array in a moderate size suburban backyard has been the wish of many hams. Although not large, the full wave loop has a great deal to offer.

In its general configuration, a full wave of wire is suspended (as a square of equal sides), at between three and ten metres above the ground. One corner, or the centre of one side, is fed with open wire line and the array matched at whichever frequency is desired. The radiation is predominantly through the plane of the antenna and, therefore, directly vertical to the ionosphere. This is of great assistance, as reflected power is toward the ground and may spread over up to 1,000 km.

There is a need to consider some aspects of the ionosphere to understand the working of such an antenna:

1. The ionosphere surface is not a clear reflecting plane as is a glass mirror. It is a most uneven surface, with sections so irregular in shape, that reflections may occur at many angles, hence the resultant broad geographic coverage (both on long distance hops or local vertical incidence paths as in this case).

2. There is a frequency above which the radio wave is absorbed by this surface, varying from time to time, season to season, known as the critical frequency.

The overall benefits of such an antenna are, therefore, good low frequency coverage over a local path and at no great expense of supports. Above the critical frequency, at perhaps 14 MHz, random lobes from the horizontal wires, which may have a reasonably low angle of radiation, can give acceptable DX performance.

A number of such low antennas may be used for multiband work. I mention them mainly in the context of their low frequency usefulness. A typical antenna may be erected as a 10 metre-a-side loop on three metre high masts, or on short poles protruding from the top of fruit trees, and give a 7 MHz signal into a nearby state comparable to a full size dipole at 15 metres, used by another ham for DX work. The principle here is never to consider your back yard too small to erect an antenna which will be effective in some way or other! The point at which such a loop is fed is more a matter of convenience than an electrical requirement, although the need to retain symmetry should be observed. I have seen some fed with coaxial cable via a balun; however, the practicality of using it on a number of bands makes the use of open wire line very attractive.

Alternative Forms

I have encountered many of these antennas with a terminating resistor opposite the feedline point, as well as some with an open circuit at this point. These may provide some with an experiment or two to work out the worth of such modifications.

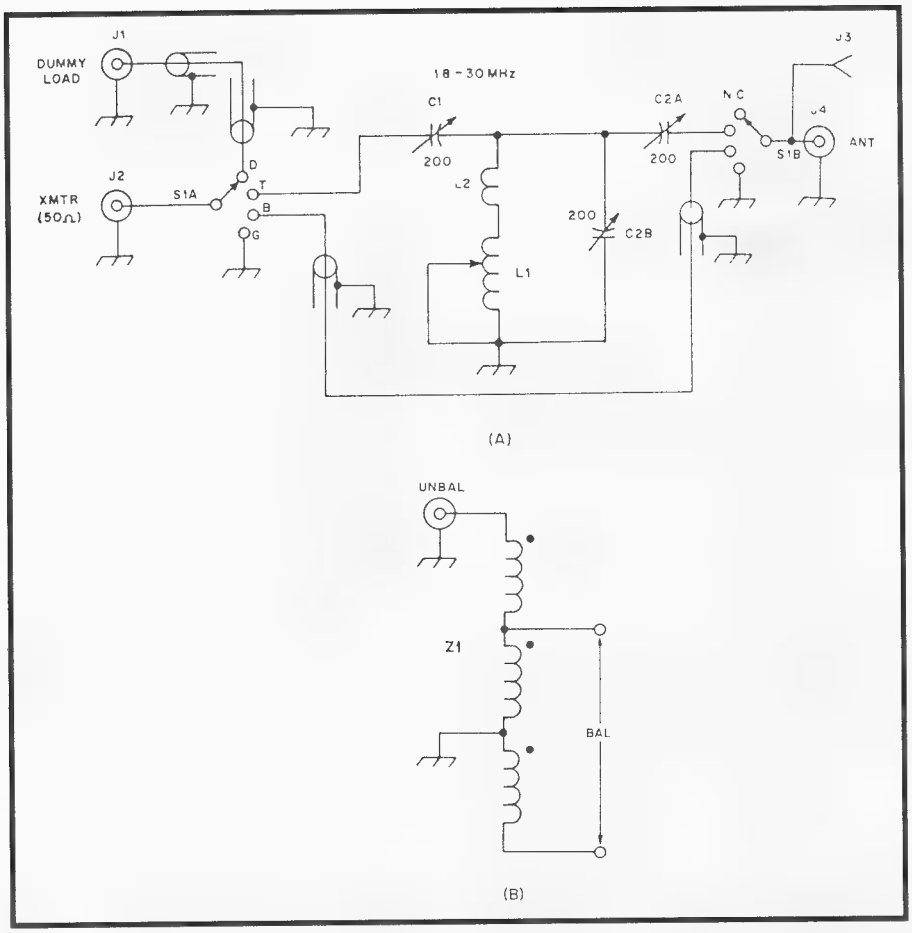

Figure 23 – Schematic diagram of the SPC transmatch. Capacitance is in picofarads.
(Reprinted from the ARRL Handbook, 1988 Edition, page 34-16)

Antenna Tuning Unit

Coupling the feedline of the antenna to a transmitter is arranged through an antenna tuning unit (ATU). This item may be treated as a "black box" that matches the impedance found at the end of our feedline, on the various bands, to the 50 ohm load impedance of our transceivers. The feedline lengths may be chosen to arrange for either a current or voltage node to be present at the ATU terminals, where either a series or parallel resonant tuned circuit would simplify the adjustments.

Modern tuning units of the "SPC" (Fig 23) or "Z Match" (Fig 24) designs are more tolerant to complex impedances and it is not necessary to use "resonant" feedline lengths with these. The components within these ATUs are altered, by the adjustment of the controls, for a reverse power between the transmitter and the ATU of zero. This completes the matching process.

Z Match Antenna Tuning Unit

The Z match antenna coupling unit has been very popular for a number of years, since it was featured in ARRL and RSGB publications, and more recently in *Amateur Radio* magazine. Many units have been described using an assortment of coil dimensions and layouts, including single and two coil set ups, and units to cover from 1.8 to 30 MHz.

I have had success with the RSGB version (Fig 24), which covers 3.5 to 30 MHz only, and have now successfully built a number of these. My modified version has been copied by several VKs, and while the RSGB description gives excellent information on coil construction, the suggested layout gives extremely long leads to the 14-30 MHz range coil, which is overcome in the modified version (Fig 25).

This layout places the higher frequency coil directly between the fixed terminal lugs on the two gang (H gang!) capacitor. On both the RSGB and ARRL circuits, each link is marked for 3.5/7 or 14/21/28 MHz, which has caused difficulties for many constructors, as some feedline lengths present impedances to the coupler which may be matched better by the alternative connection.

I solved this problem by using a 3-position, 2-pole switch which allows the twin feeder to be connected to either link (positions 1 and 2) or to the external terminal mounted on the rear panel of the coupler (position 3). This last terminal allows the twin feeder to be used as a top-loaded vertical antenna on 1.8 MHz through an additional antenna coupler, or as a general coverage receiving antenna.

The coils may be 63 mm and 75 mm in diameter, as shown in the diagrams, and 14 to 16 SWG wire is suitable. The coils should first be wound around a cylindrical former (eg an electrolytic capacitor) of smaller diameter, and then threaded into the holes in the perspex support. A suitable adhesive (eg plastic

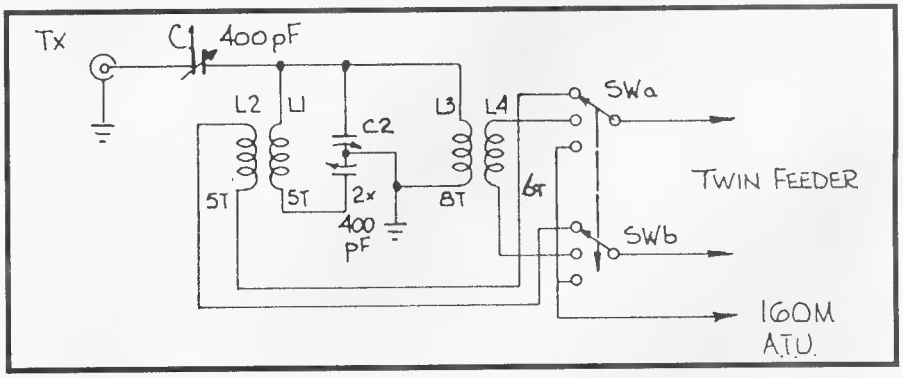

Figure 24 – The Z Match.
(Reprinted from Amateur Radio, September 1984, page 17)

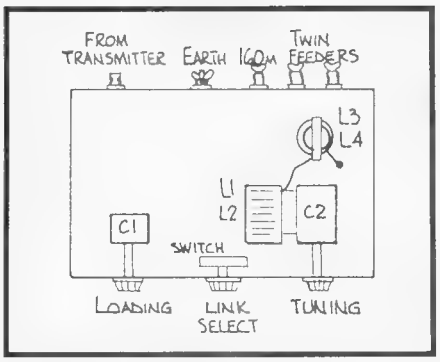

Figure 25 – The Z Match layout.
(Reprinted from Amateur Radio, September 1984, page 17)

cement) may be used to fix the coils in the holes (Fig 26).

For power up to 100 watts, standard single- and two-gang broadcast receiver tuning capacitors are quite suitable, with Stromberg "H" gangs preferred. For higher power, a pair of transmitting variable capacitors, with adequate plate spacing, should be used. Note that C1 needs to be insulated from ground and from the COUPLING control knob. The frame and rotor of C1 should be connected to the transmitter output, while the stationary plates should be connected to L1.

A most essential requirement is the use of vernier dials on the drive shafts of the two capacitors. It is impossible to tune capacitors of these maximum values with the fine accuracy needed to set the match correctly, without such dials.

The "Z" match is constructed on a simple U-shaped chassis, with a second U-shape of perforated metal as a top cover. The front panel controls are LOADING, LINK SELECTION and TUNING.

The unit should be used with a good earthing system. A minimum 1.5 m length of 20 mm galvanised water pipe should be driven into the ground immediately behind the antenna coupler and, from an earth clamp on this pipe, a length of 6 mm^2 or larger copper wire run to the earth terminal on the ATU. One to two metres of wire should be enough. Additionally, bonding of this earth system to nearby water pipes, galvanised steel carports or other metallic structures will improve efficiency when using unbalanced-feed antennas.

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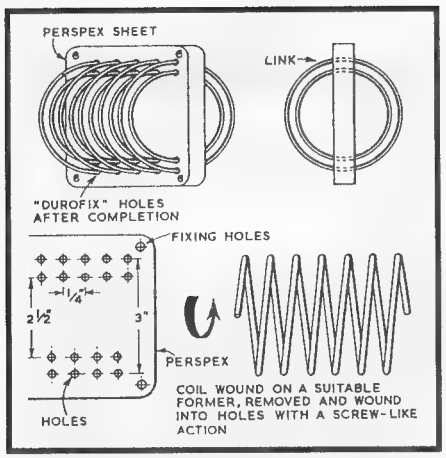

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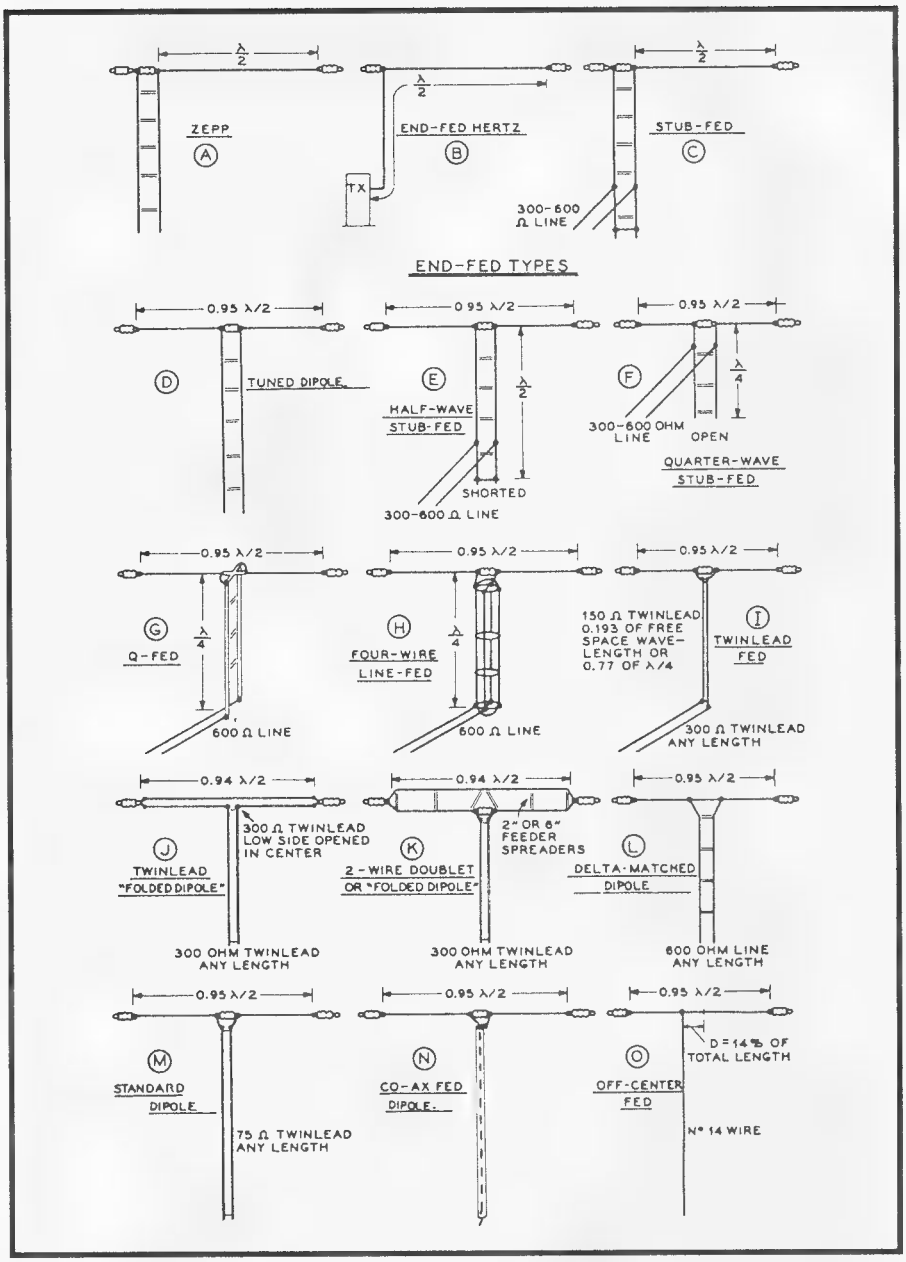

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